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UNITED STATES DEPARTMENT OF AGRICULTURE

Control of the Locust Borer[1]

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The United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, In Cooperation With the Forest Service and Ohio State University

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INTRODUCTION

The locust borer (*Cyllene robiniae* (Forst.))[2] is a very destructive forest and shade-tree insect widely distributed in the United States and Canada. Injury to trees is caused by the larvae, or grubs, and consists of large burrows in the sapwood and heartwood (fig. 1) of the trunk and larger branches. Although the trees may not always be killed outright, a heavy infestation renders them unfit for useful products or disfigures them for ornamental purposes. Trees may be so badly weakened by this insect that a slight wind will cause them to break off at points of serious attack (fig. 2).

INCREASING SERIOUSNESS OF THE BORER PROBLEM

Because of its important soil-binding and building capacity and its extensive root development, black locust (*Robinia pseudoacacia* L.) has been used very widely in recent years in soil conservation programs throughout the United States. The larger proportion of these trees have been planted on soils badly eroded by wind or water and severely depleted of soil nutrients by poor farming practices. Such plantings furnish an ideal environment for the locust borer and create conditions favorable for high larval survival and subsequent severe damage. For this reason the locust borer problem is assuming increasing importance in all such areas where black locust has been extensively planted. It is particularly important in the farm economy of the Midwest and central South. Although the primary purpose

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[1] The basic data on which this circular is founded were collected at a temporary laboratory of the Bureau of Entomology and Plant Quarantine located at Columbus, Ohio, in cooperation with the Central States Forest Experiment Station and Ohio State University. This investigation covered a period of approximately 7 years beginning June 1, 1931. Intensive studies were conducted and permanent sample plots established in Ohio, Indiana, Illinois, Kentucky, Tennessee, Michigan, Pennsylvania, and New York. Hence a great variety of conditions of tree growth and borer damage have been studied.

[2] Order Coleoptera, family Cerambycidae.

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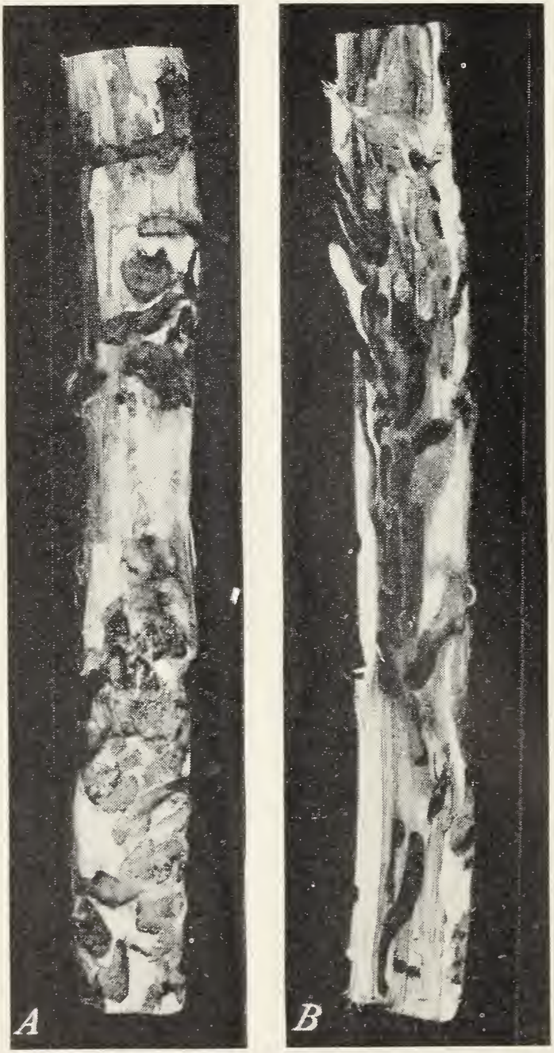

FIGURE 1.—Severe locust borer attack on black locust, showing a section of the tree with bark removed, and split down the center: *A*, The cambium region under the bark, showing the tunnels in the sapwood; *B*, interior of the same stick, showing the tunnels of the full-grown larvae, and the pupal cells.

of these plantings has been to control soil erosion, it seems obvious that these erosion plantings should also, if possible, be made to produce post and pole material for the farmer so that he may again realize a return from eroded and depleted land. This can only be accomplished if the locust borer can be satisfactorily controlled.

It is recognized that some soils are so badly eroded, compacted, or depleted that it will be impossible to produce locust material of commercial value for a number of years. On such soils the prime need is that of erosion control or soil improvement. Under such planting conditions it may be impossible to initiate any satisfactory method of borer control. If such plantings fulfill the requirements of soil improvement and erosion control, however, that may be all that can be reasonably expected.

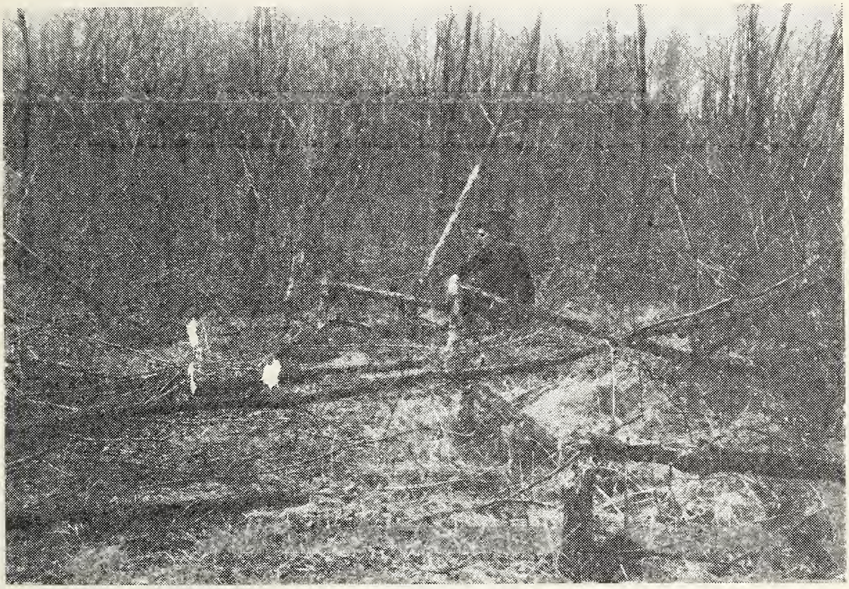

Figure 2.—A 14-year-old stand of planted black locust near Minerva, Ohio, severely injured by the locust borer.

In the present National Forest planting program in Region 9, north of the Ohio River, more and more emphasis is being placed on the site requirements of different tree species. It is now recognized that certain heavy, compact, depleted soils do not furnish a satisfactory planting site for black locust, and that it is a mistake to plant black locust indiscriminately on all plantable areas. Recent experience has shown that some of the native conifers have greater promise of producing merchantable products than has black locust on certain soil types.

DESCRIPTION, LIFE HISTORY, AND HABITS OF THE LOCUST BORER

The adult (fig. 3) is a long-horned beetle about three-fourths of an inch in length. It is deep velvety black, marked with bands of bright yellow. The adults are found in large numbers on goldenrod (fig. 4) late in the summer or early in the fall. The flowers of this plant furnish the principal food of the beetles, although such food is not necessary for normal development and egg laying. The females deposit their eggs in the rough crevices of the bark or around wounds (fig. 5, *A*) on black locust, from about the last part of August to the middle of October. The eggs hatch in about 1 week and the young larvae, or grubs, bore their way into the inner bark, where they pass the winter in a dormant state (fig. 5, *B*).

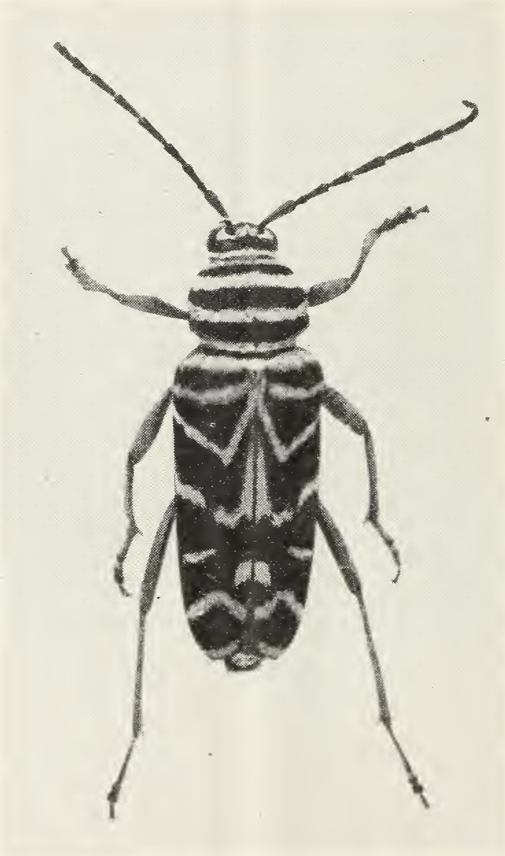

FIGURE 3.—Adult of the locust borer (*Cyllene robiniae*), × 3.

Early in the spring, at about the time the buds begin to swell, the larvae resume their activity and finally work into the woody portion of the tree. Up to this point they have caused little damage, but as the larvae increase in size and tunnel the woody portion of the tree they often penetrate deeply into the wood and cause serious damage by mechanically weakening the tree. In the Central States the larvae reach full development (fig. 6) during August, then pupate (fig. 7), and emerge as adults late in August or early in September.

In the South full development and emergence may occur about 2 weeks earlier, and farther north somewhat later.

The presence of the young borer larvae under the bark of the tree is easily detected early in the spring about the time the leaves begin to unfold. New attacks are then indicated by characteristic wet spots and the brown or yellow pellets of excrement pushed out of openings through the bark at the entrances to the larval galleries. After the larvae have entered the wood of the tree they push out white or yellowish excrement or "sawdust" through these openings (fig. 8, *A*). Old attacks are readily recognized by calloused swellings of growth on the trunk, by dead limbs, or by borer holes extending into the wood (fig. 8, *B*).

FIGURE 4.—Adult locust borer on a spray of goldenrod.

FACTORS INFLUENCING BORER DAMAGE

The expected return from plantations of black locust on poor soils inevitably will be low with many plantations of this character; therefore it is essential to keep the cost of locust borer control correspondingly low, and the application of direct methods that might be used in protecting shade trees is impractical in such plantations for economic reasons. Careful studies of the factors affecting the locust borer under various conditions and in different localities were made with the hope that some of them might be regulated by simple and inexpensive means so as to make conditions unfavorable for the borers and thus present excessive damage. A discussion follows of some of the factors that have been found to have an influence on locust borer survival and resultant injury.

TREE VIGOR

A very close relationship appears to exist between locust borer damage and the vigor of the tree. The more vigorous the tree, the less is the borer injury. Furthermore, within stands of locust over 10 years of age a close relationship exists between crown class[3] and locust borer injury, the dominant crown class suffering the least injury and the overtopped class the most. So it appears that thrifty trees are able to overcome attack, whereas slowly growing, overtopped trees often succumb or are so badly injured that they have no commercial value.

That thrifty tree growth is the cause, and not the effect, of relative immunity from locust borer damage has been definitely shown by a study of the survival of young borer larvae. Eggs are deposited

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[3] The trees are classified according to the position the tree crown occupies in the stand. Dominant trees, the most vigorous trees in the stand, are those whose crowns are above the general level of the canopy. Codominant trees are not so tall as the dominants, but receive full overhead light. Intermediate trees are not so tall as the codominants, receive partial overhead light, usually have small crowns, and are less vigorous than codominants. Overtopped trees are those shorter than the intermediate, with little or no overhead light, and are the least vigorous trees in the stand.

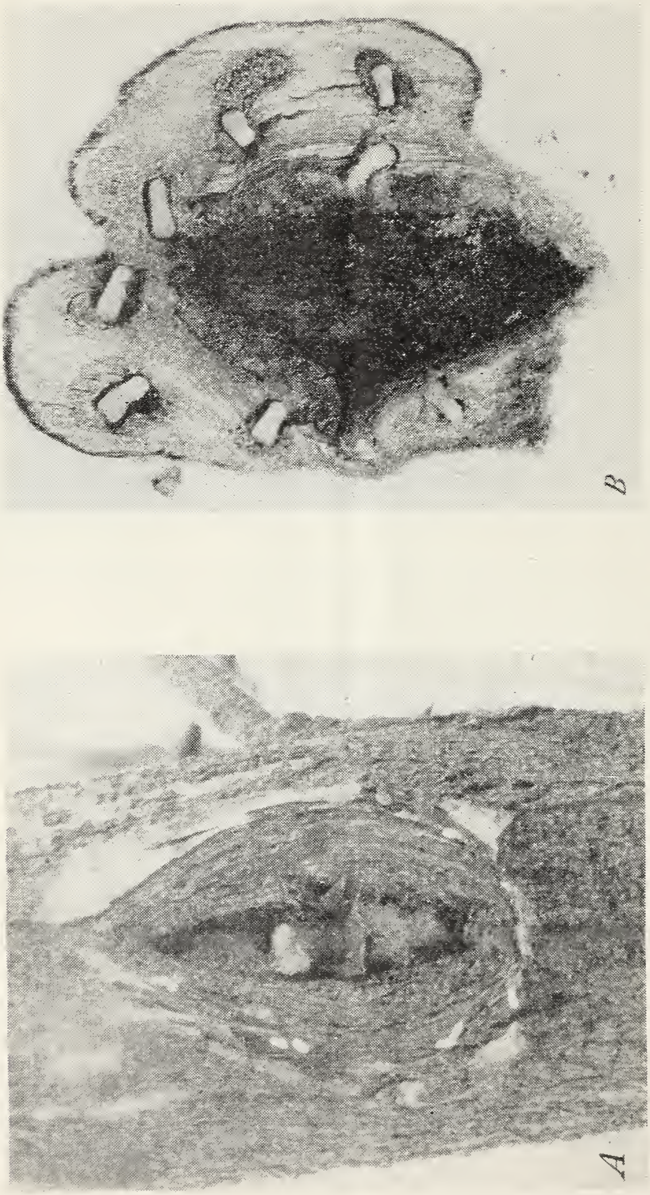

FIGURE 5.—*A*, Two-year-old black locust sprout with seven eggs of the locust borer laid around an old fungus wound and exposed by breaking away the bark scales; *B*, eight young larvae of the locust borer in hibernation cells in wound tissue in the bark around an old scar, × 3½.

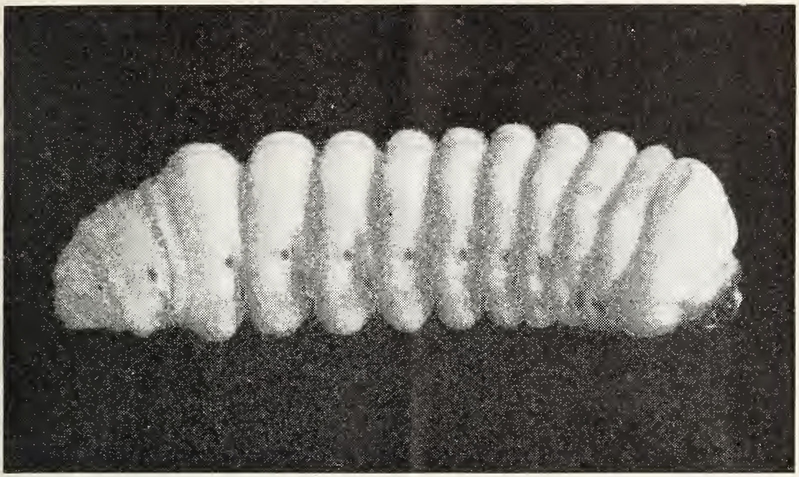

FIGURE 6.—Full-grown larva of the locust borer, × 3½.

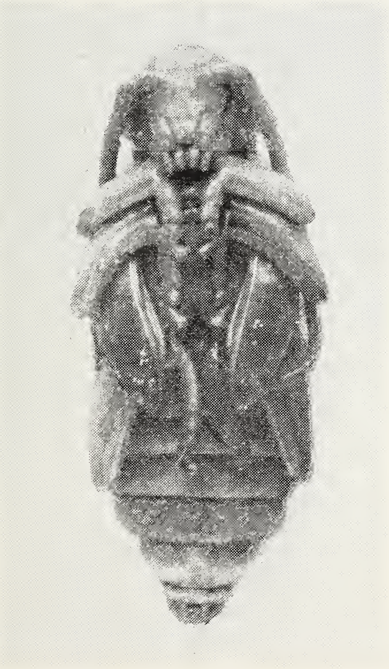

FIGURE 7.—Pupa of the locust borer, × 3½.

indiscriminately on trees of all crown classes. Nevertheless there is a definite difference in the number of larvae that survive in trees in the different crown classes. In the upper crown classes there may be practically no survival of young larvae, but in the lower crown classes an average of about 50 percent of the larvae will reach the adult stage. From the standpoint of production of adult borers the lower crown classes produce over 75 percent of all the borers in most stands. The reason for the lower survival of larvae in the more thrifty trees has not been determined. Apparently it is correlated with rate of growth, but the determining factor may be moisture. It has been definitely shown that rate of larval mortality is at its highest point early in the spring at the time when tree growth is most rapid.

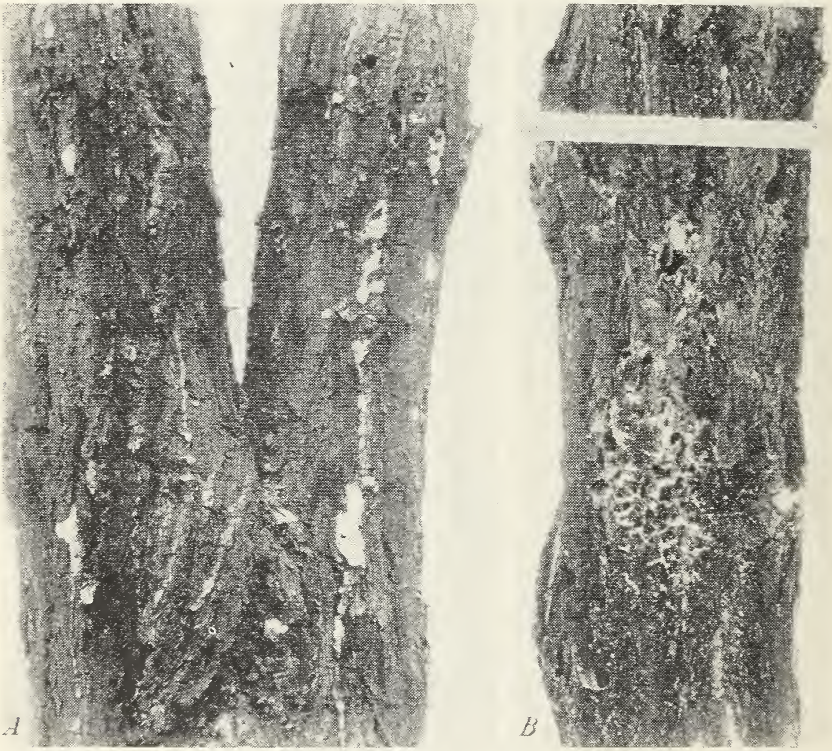

FIGURE 8.—*A*, trunk of black locust tree showing evidence of heavy attack by the locust borer. Patches of white "sawdust" indicate the approximate location of young larvae in the wood of the tree; *B*, section of trunk of a black locust with 11 emergence holes of the locust borer.

LIGHT AND TEMPERATURE

In his early work on the borer Craighead[4] pointed out that there appeared to be a close relationship between shade and freedom from locust borer attack. While the results of this later investigation have not entirely substantiated his theory, there appears to be a high degree of correlation between shade and freedom from serious injury. This may be due to the indirect effect of shade on oviposition because of lower temperatures in densely shaded stands.

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[4] CRAIGHEAD, F. C. PROTECTION FROM THE LOCUST BORER. U. S. Dept. Agr. Bul. 787, 12 pp., illus. 1919.

Observations made during the present study show that temperature appears to be the principal limiting factor in oviposition. When daily maximum air temperatures are over 75° F. the females show a definite preference for shaded portions of the tree trunks, but when the daily maximum air temperature is below 70° they show an equal preference for sections of the trunk receiving full sunlight. At temperatures of from 70° to 75° little preference is shown for either part of the trunk. During the spring of 1937, following a warm fall the previous year, more larvae were found consistently in shaded portions of the stand than in those portions more exposed. During the spring of 1938, however, which followed a much cooler fall, the reverse was true, and more larvae were found in the exposed portions of the stand. Inasmuch as the weather is usually predominantly cool in the fall during the period of oviposition, a stand of locust which is densely shaded should, on the average, other factors being equal, receive fewer eggs than one which is more exposed to light. The wound shown in figure 5, *A*, was on the north side of a trunk near the ground and in almost 100-percent shade, showing that oviposition may take place in complete shade. That light in itself is not a limiting factor in oviposition was shown by the fact that females laid eggs at least 1 hour after sunset on several days when the maximum air temperature had been over 90°.

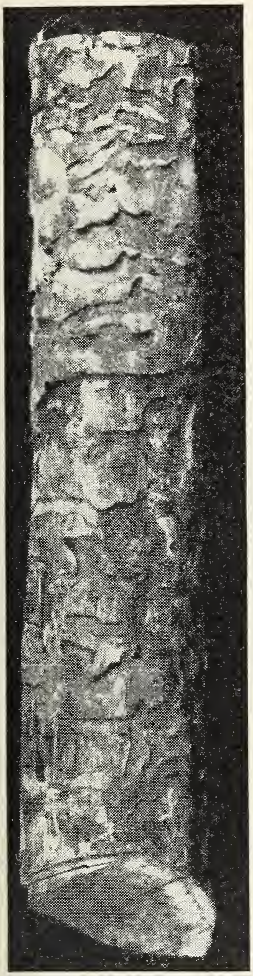

FIGURE 9.—A peeled section of black locust, showing the cambium-feeding habits of the locust borer during periods of severe drought.

DROUGHT

Although black locust can be established on very dry, exposed sites, it is very seriously injured by prolonged periods of drought, particularly on soils which normally have a high water table and high moisture content. Black locust is normally a very shallow-rooted species which does not produce a taproot, and therefore the sudden lowering of the water table causes serious damage. Drought plays a very important part in creating conditions favorable for locust borer development by the reduction of growth rate and general vigor of the stand. Repeated examples have been noted in which thrifty stands of locust had practically no borer injury previous to a drought year, but were completely killed after the drought by the combined effects of the drought and the locust borer. It is likely that many such stands which were killed in this manner might have survived were it not for the complete change of feeding habits of the locust borer during periods of extreme drought. The locust borer normally bores both in the phloem and the wood, but during drought periods it becomes strictly a phloem feeder (fig. 9), thus increasing greatly the girdling effect.

Drought conditions were artificially produced for 3 years on a permanent sample plot near Hopedale, Ohio, by the construction of a low shed on the top of a ridge of a spoil bank.[5] The trunks of the trees extended up through the roof of the shed, but the roof prevented practically all rainfall from reaching the ground on the plot, and created very arid conditions in the soil during the period of treatment. There was consistently less tree-diameter growth and greater locust borer survival on the roofed-over plot than on the adjacent check plot which received rainfall.

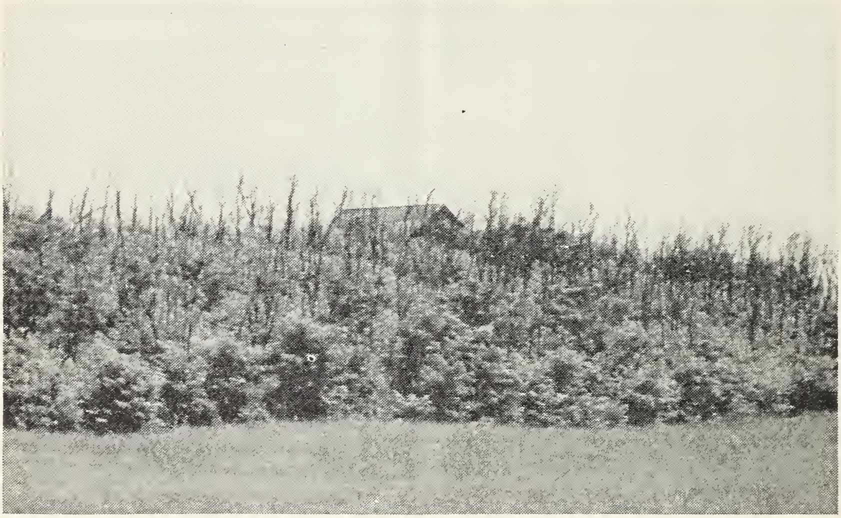

FIGURE 10.—A 20-year-old stand of black locust near Washington, Ind., the stems of which were killed by the combined action of drought and borer injury. Note the prolific sprouting of all these trees.

Drought injury is often confused with locust borer injury; but if injury is caused by extreme drought, practically every tree in the stand will be equally affected (fig. 10), whereas injury caused by the borer alone will be more spotty, and even in instances of extreme attack some trees will be more severely injured than others.

FIRE

During the early part of its life, while the bark is still smooth and thin, black locust is very susceptible to fire damage. During this period even light surface fires may kill the trees. As its age increases, locust becomes more resistant to fire, and when mature will often withstand a severe fire. The effect of fire in reducing site quality is of great importance, for the inevitable result of burning off of leaf-mold and litter is decreased vigor or growth, which then leads to increased borer damage. Complete protection from fire should be provided on any area planted to black locust.

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[5] A spoil bank is formed by the piling up of earth removed by steam shovels in surface mining for soft coal.

Grazing of Livestock

The detrimental effect of pasturing black locust stands may be both direct and indirect. Direct injury may result to young trees by cattle and sheep browsing on the foliage and young succulent growth. When sheep and cattle have access to locust during the winter, they will often completely girdle the trees and cause their death. Sheep appear to be destructive to young locust, whereas cattle seem to do more damage to large trees, even killing trees up to 12 inches in diameter. Heavy pasturing in black locust stands has a decidedly detrimental effect on site quality through an undesirable compacting of the soil. As has been mentioned, any factor which tends to reduce quality of site has an indirect effect in inducing injury by the locust borer.

Pruning

Preliminary investigations indicate that pruning black locust may very definitely create conditions more than ordinarily favorable for locust borer attack. Cracks and crevices formed around the callous tissue after pruning makes ideal places for eggs to be laid (fig. 5, *A* and *B*). Also, unless pruning is very carefully done, there is a certain amount of bruising and breaking of bark, which creates additional ideal places for oviposition by the borer.

Pruning in black locust should be kept at a minimum, and should be used only for improvement of form. It should be done in August when the water sprouts which form subsequently will be shorter lived and less vigorous than those resulting from pruning at any other time of year.

RECOMMENDATIONS FOR SILVICULTURAL METHODS OF CONTROL

In view of the close relationship between tree vigor and locust borer injury, anything that can be done to increase the vigor of a stand will aid in minimizing injury. Clear-cutting for the production of vigorous sprout growth, thinning, mulching, and the use of mixtures and superior varieties of black locust are some of the silvicultural methods tested. The types of stands to which one or more of these are applicable include slowly growing young stands, older stands with moderate or severe damage, mixed plantings, and new plantings.

Again it should be pointed out that from the standpoint of the production of merchantable stands of black locust the soil requirements of this species should be carefully considered and that planting on heavy, compacted, or depleted soils should be avoided.

Control in Slowly Growing Young Stands

The treatment proposed for slowly growing young stands will be applicable to a high percentage of stands of locust that are being planted for erosion control. Many instances have been observed during the progress of this study where a planted stand of locust has grown slowly for the first few years and ultimately the stems have been killed by borers. In practically every case the stems so killed have sprouted at the root collar, and the resultant rapidly growing sprouts have usually suffered very little from borer attack (fig. 11). Inasmuch as there is a high degree of probability that slowly growing stands will eventually suffer serious borer attack, it is proposed that these stands be cut back at an early age before any serious attack has been made, but after sufficient time has elapsed to indicate the growth rate of the planted trees. The more vigorous sprouts which follow this cutting may reasonably be expected to suffer less from the borer because of the low survival of young larvae in them. This cutting should ordinarily be made about 5 or 6 years after the trees have been planted, by which time the rate of growth will be evident.

Sprout growth has been observed on experimental plots for about 5 years, but it is not known at this time how long this rapid growth and apparent resistance will be maintained.

An injury-prediction chart based on early height growth is presented in figure 12. By obtaining the height of the dominant trees in a young stand of about 5 or 6 years of age, it is possible to determine the probable future borer injury. If the height-age point falls in the band of severe to medium injury, it is suggested that these young plantings be cut some time during the dormant season, preferably during the winter. This treatment should be followed, after the second year's growth, by a thinning in the sprout clumps, in which all but the best sprout in each group are removed. This thinning operation should be made preferably during the month of August, so as to insure the minimum production of new sprouts.

Control in Severely Injured Stands

It is proposed that severely injured stands be clear-cut during the dormant period of growth, as suggested originally by Craighead,[6] and that dependence be placed on regeneration by sprouts. There are numerous instances where such treatment has resulted in a good second crop of trees with very light subsequent injury. As in the preceding method, the resulting sprout stands should be thinned by the removal of all except the most thrifty sprout in each group.

Control in Moderately to Lightly Injured Stands

Thinning is the form of control especially adaptable to stands of locust on medium to good sites. These are the stands that naturally fall in the upper two bands on the injury-prediction chart (fig. 12). On such sites severe injury is quite largely confined to overtopped, inter-

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[6] See footnote 4, p. 8.

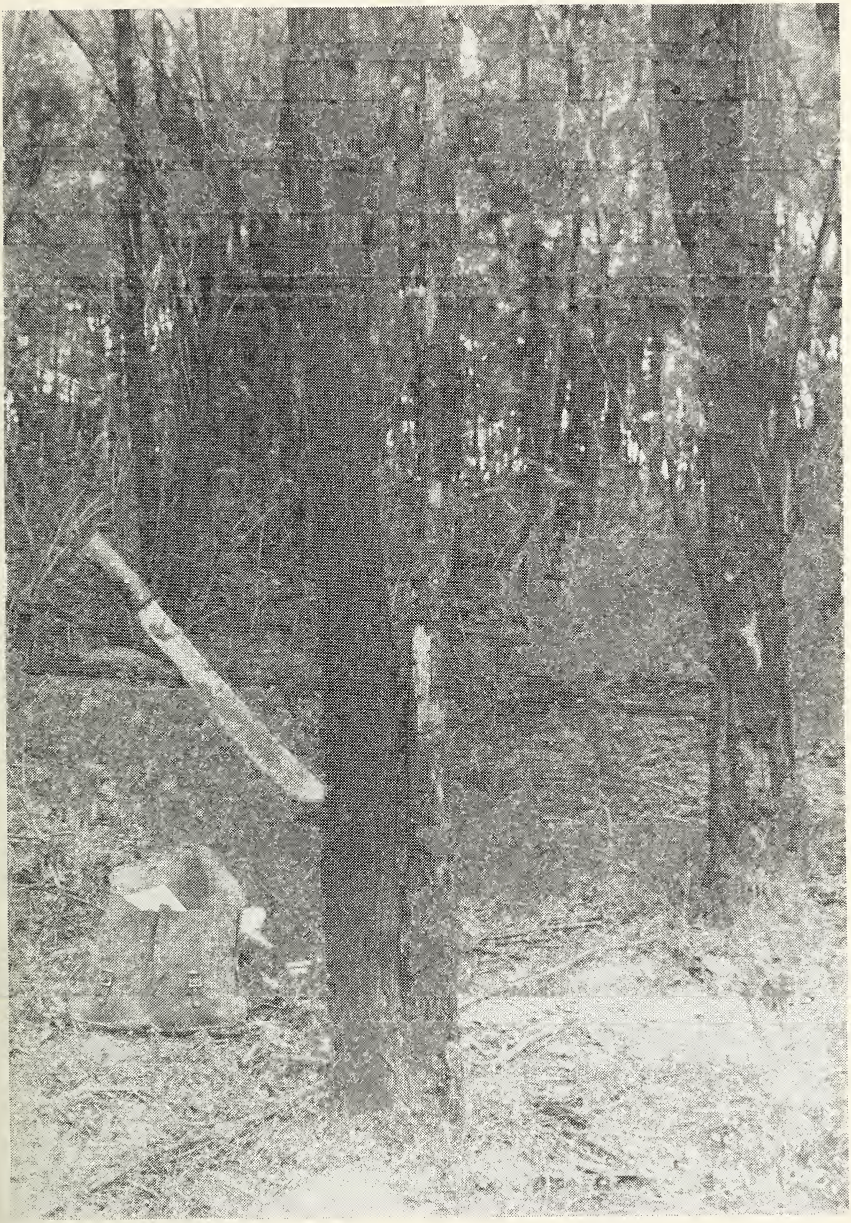

FIGURE 11.—A railroad locust plantation near Petersburg, Pa. Note that the original trees have practically all been killed by the borer and that the sprouts from them are practically free from borer injury. This illustrates the effectiveness of vigorous sprout growth in preventing borer injury.

mediate, and otherwise decadent trees. After dominance has been asserted in stands on such sites, a thinning operation designed to remove the infested trees should result in an adequate reduction of the borer population to protect the fast-growing trees. These thinnings should be made in August or September when black locust produces sprouts of minimum vigor. Thinning treatments of this nature have a twofold effect. (1) They greatly reduce the number of trees that are suitable host material for the borer and (2) they reduce competition for light, soil moisture, and nutrients for the dominant and codominant trees which remain. This will reduce the total borer population in a stand, and the borers that remain will find the trees of the residual stand that have been relieved of competition more resistant because more vigorous.

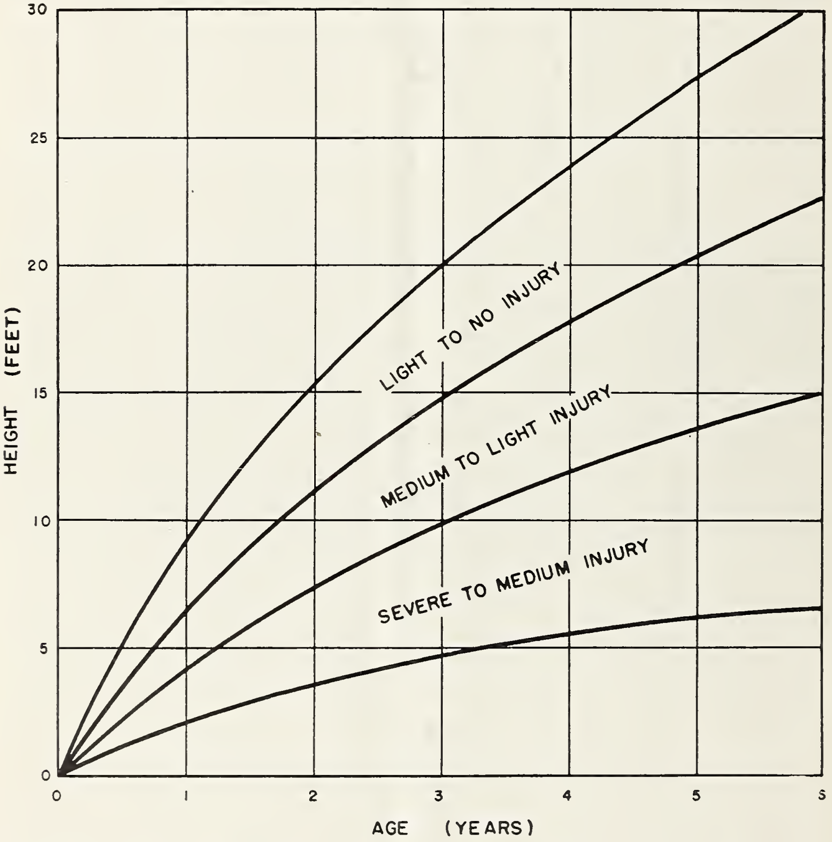

Figure 12.—Injury-prediction chart based on early height growth of dominant and codominant trees. To use this chart: Locate the point corresponding to the average age and height of the dominant and codominant trees; probable injury is indicated by the band in which this point falls.

Control in Mixed Plantings

It is an accepted fact that some tree species grown in mixture with other trees suffer less from insects or other enemies than when grown

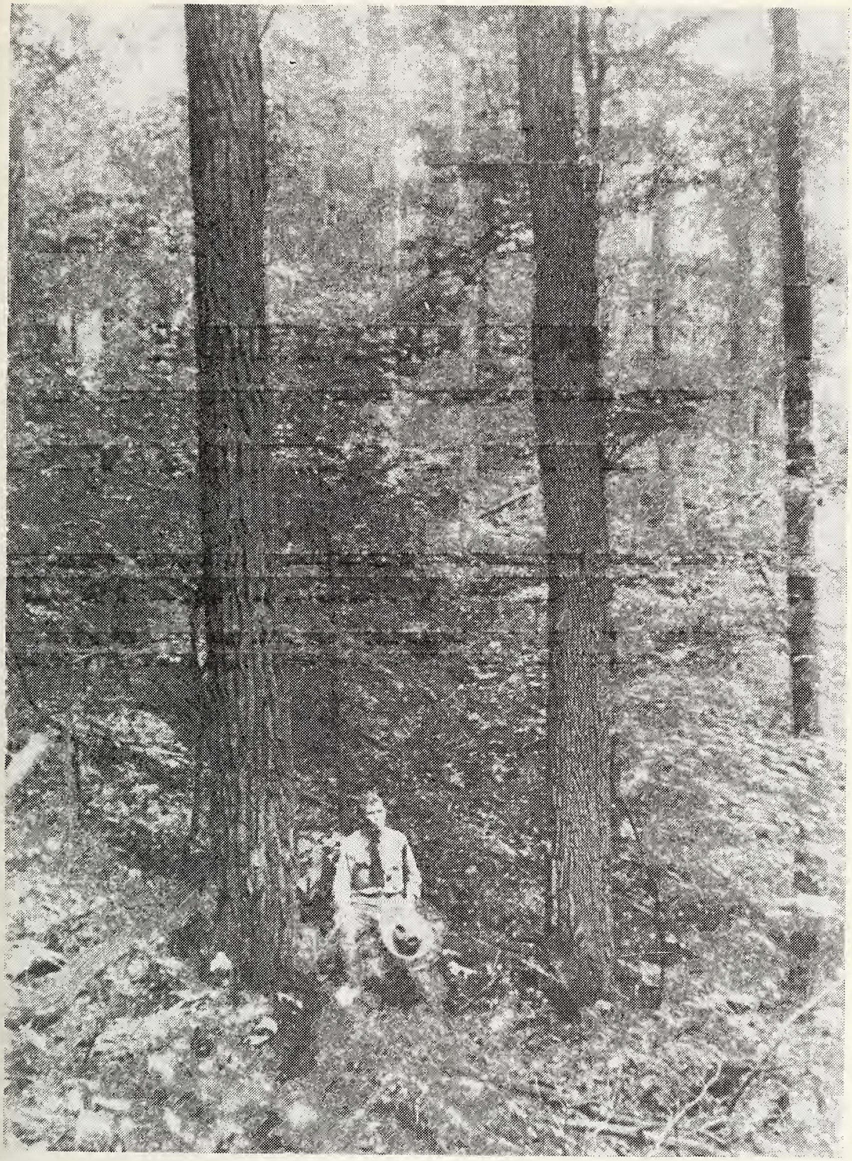

FIGURE 13.—Mature black locust in its native habitat on Pisgah National Forest near Marion, in the mountains of North Carolina. The tree on the left is 53 years old. Locust trees growing in such mixtures rarely suffer injury from the borer.

in pure stands. Confirmation of this has been repeatedly observed in the case of black locust (fig. 13), where locust borer injury is usually much less when the tree occurs in mixtures rather than in pure stands. The foliage of a pure stand of locust does not produce dense shade or an abundant leaf litter. When its leaves are combined with the leaf fall of other trees, particularly hardwoods, a soil-protecting and soil-building litter becomes established which tends to increase the productive capacity of the site, thereby creating a less favorable environment for the borer in the thrifty trees so produced. Further study is necessary, however, on the type of mixture to be used for this purpose, as the kind of soil on which locust is to be planted may often be too poor to support other desirable hardwood trees.

Mulching

Mulching young black locust plantations to a depth of several inches with hardwood leaves has given encouraging results in the way of accelerated height and diameter growth for a period of several years after the application. In some instances this accelerated growth has been accompanied by a marked decrease in the number of borers that are able to survive.

This method of indirect control seems to build up the soil by the addition of organic matter, as well as greatly to improve its water-holding capacity. It is very limited in its application, because of its high cost, but it may have promise in certain areas where cost is not of prime importance, such as around shade and ornamental trees.

If a farmer is primarily interested in growing black locust for post or pole production, he should plant this species in portions of his wood lot where the stand is very sparse. Practically every farm in the Central States that has a wood lot has portions which are parklike and badly understocked. Black locust should be planted in large openings in such stands, but never closer than 10 feet to existing large trees. It is well in such cases to plow a wide furrow for the planting, as this will serve as an ideal catch basin for the leaf fall from the larger trees, thereby insuring a concentrated continuous hardwood leaf mulch around the planted trees.

There are numerous instances in the Central States of such "reinforcement" plantings where black locust has grown remarkably well and usually with little or no locust borer damage.

Sanitation Cuttings

Whenever locust is to be planted it is advisable to make a survey of all the native and planted locust in the general vicinity and remove all severely injured or decadent trees which might be serving as brood trees for the locust borer. In some sections of the Central States it is quite common to find old, decrepit trees with their tops stag-headed and partly broken, making ideal brood trees owing to their generally unhealthy condition. Infested trees should be cut during the dormant period, and either burned or peeled to destroy the larvae.

Use of Superior Varieties of Black Locust

During the progress of the study on the locust borer, areas were observed where certain varieties of black locust, with excellent form, appeared to be highly resistant to injury by the borer. Two outstanding examples of this apparent resistance occur in shipmast locust on Long Island and "Higbee" locust in southern Indiana. In the latter

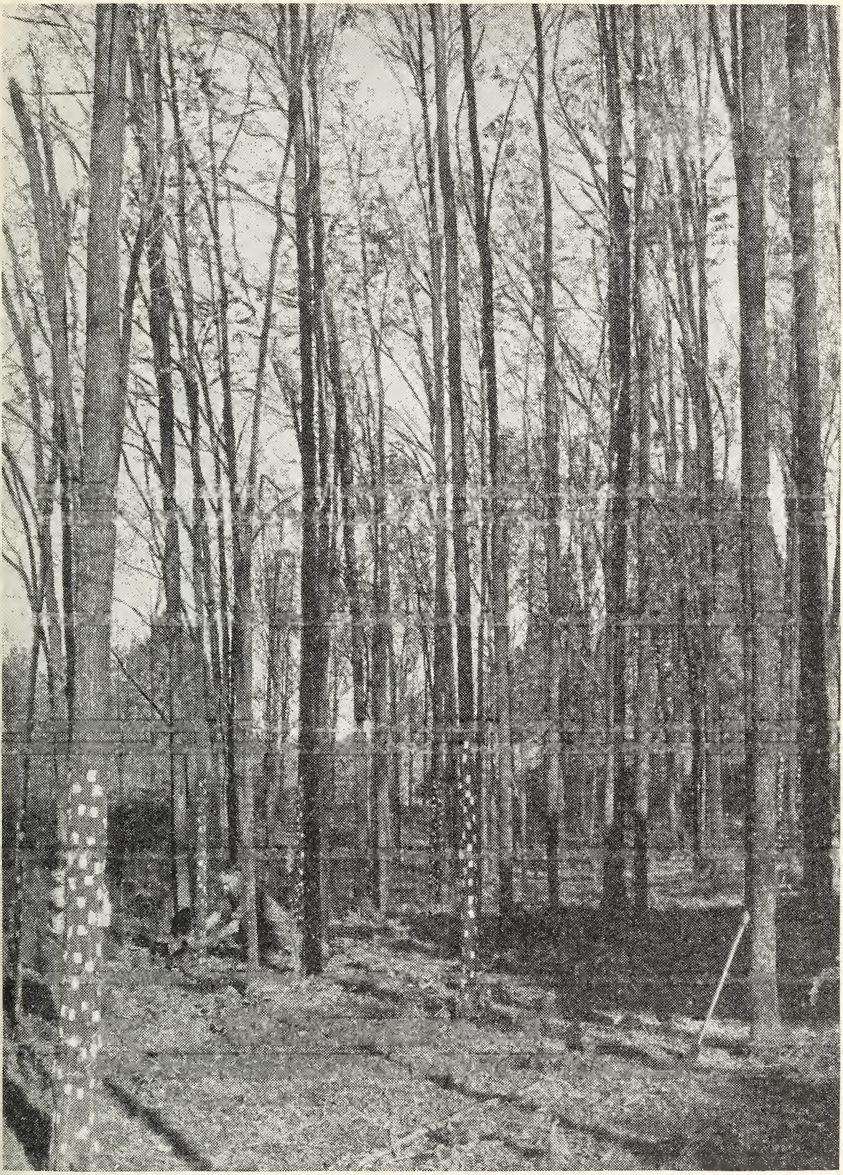

Figure 14.—An excellent stand of "Higbee" black locust of sprout origin 16 years of age and averaging about 50 feet in height. This stand has practically no borer injury. The white patches on the bark indicate points where larvae were introduced to test the relative resistance of this stand to the locust borer. Near Madison, Ind.

case this apparent resistance has been tested over a period of 4 years by the artificial application of over 2,000 locust borer larvae on certain trees (fig. 14). Of this total number of larvae applied, less than 20 survived to the adult stage. These 2 varieties are being further tested in field plantings in the Central States, but it will be several years before their resistance can be considered established. From the standpoint of form alone, however, these and other desirable varieties should be given more consideration in future planting programs.

NATURAL CONTROL

Of the natural enemies of the locust borer, this study has shown that woodpeckers are by far the most important. The downy woodpecker and hairy woodpecker are of great local importance in early spring in destroying the young larvae shortly after they have begun to be active. At Cambridge, Ohio, on 50 acres of permanent sample plots, these birds removed on the average about 30 percent of the locust borer larvae each year over a 4-year period. The unfortunate part about these predators is that they are not so effective in certain other areas. The owner of a locust plantation would do well to encourage these woodpeckers to stay in the vicinity by furnishing them with suet at the time they would migrate or by the erection of suitable nesting places such as old decayed posts or tree trunks. The red-headed woodpecker often removes a small percentage of full-grown larvae or pupae, but its work, like that of the downy woodpecker and the hairy woodpecker, is very spotty.

During the course of this 7-year study insect parasites have only occasionally been found, and have destroyed on an average less than 1 percent of each year's crop of borers.

SPRAYING

The cost of direct control measures is usually prohibitive in large plantations, but may be warranted in the case of ornamental trees or small planted areas. No entirely satisfactory chemical that will give complete control has been developed. The most effective is orthodichlorobenzene.[7] This is prepared for use as follows: Make a stock emulsion of 1 gallon of orthodichlorobenzene, 1 gallon of soft water, and 1 pound of fish-oil soap or common laundry soap. The soap is dissolved in boiling water, and after the mixture has cooled sufficiently the orthodichlorobenzene is added. To 1 part of the stock emulsion add 6 parts of soft water to make the spray material. The spray should be applied so as to cover the trunk of the tree completely, especially from the ground line up to 5 or 6 feet, and when the air temperature is above 70° F. Early spring, when the locust leaves are just beginning to unfold, is the best time to spray.

CAUTION.—As certain lots of crude orthodichlorobenzene which have been used experimentally have shown a toxic effect on the tree, the spray should be applied to one or two trees at first to test it for the toxic effect. If after 1 week no signs of leaf wilting or burning are noted, it will be safe to complete the spraying.

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[7] ST. GEORGE, R. A., and BEAL, J. A. NEW SPRAYS EFFECTIVE IN THE CONTROL OF THE LOCUST BORER. Jour. Econ. Ent. 25: 713–721. 1932.

SUMMARY

The locust borer severely damages its host trees by making large tunnels in the sapwood and heartwood which render the wood useless for posts or construction work and may often cause the tree to break and fall.

Black locust is being extensively planted for soil-binding purposes on eroded lands, and this circular deals largely with the protection of these young plantations.

The adult is a long-horned beetle, about three-fourths of an inch in length, which lays its eggs in rough crevices of the bark or around wounds. The insect hibernates as a young larva in the inner bark of the tree and bores into the wood the following summer.

Recent investigations, covering a 7-year period, carried on at Columbus, Ohio, have shown that a very close relationship appears to exist between damage by the locust borer and tree vigor. The more vigorous the tree the less is the borer damage. Factors that reduce the vigor of the tree tend to increase its susceptibility to borer injury. Important among these factors are drought, fire, and grazing of livestock. On the other hand, factors that stimulate growth rate tend to reduce the susceptibility of a tree to borer injury.

Certain silvicultural methods, designed to improve growing conditions, have demonstrated considerable promise in borer control. These include clear-cutting, thinning, mulching, and the use of mixed plantings. Of these, clear-cutting appears useful in slowly growing stands where cutting of the trees is followed by very rapid growth in the sprouts which develop from the stumps. Thinning is applicable in moderately to rapidly growing stands, where the more slowly growing and highly susceptible understory trees are removed to reduce the borer population and to make conditions for growth more favorable in the residual stand by reducing competition for light, moisture, and soil nutrients. Mixed planting has promise in the establishment of new plantations on soils which will support other broadleaved tree species. Mulching with hardwood leaves, because of the cost, is limited to trees of high value. Mulching effects may be obtained at very low cost, however, by interplanting black locust in existing open-park woods. The use of superior varieties of black locust appears to offer some promise of control.

Control, other than silvical, includes that by natural enemies and by spraying. Woodpeckers are the most important natural enemies observed, but are important only locally. Orthodichlorobenzene is the most promising spray material yet developed, but it is too expensive for use except in rare instances.

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